DEMAND-SIDE MANAGEMENT SCREENING TOOL FOR ARMENIA

PROJECT DESCRIPTION

This was prepared in response to USAID Contract no. LAG-I-00-98-00005-00, Task Order no. 9 for Armenia. The overall objective of Task Order no. 9 was to enhance the data and information on energy usage and to provide tools that can be used to develop an energy strategy for the country. One objective of this subtask was to develop a computer screening model that could be used to evaluate possible demand-side management (DSM) programs and other energy efficiency measures in Armenia. The purpose of this report is to describe the model that was developed and data collected for a number of measures. The actual results of the analyses and their implications are included in another Hagler Bailly report entitled *Armenia Demand-Side Management Final Report* also prepared as part of Task Order no. 9.

The measures that demonstrate positive results from the model could be included in an overall energy efficiency strategy for Armenia. One of the goals of such a strategy is to reduce the future need for additional electric generating resources that may be required to replace the generation from the Medzamor nuclear plant, due to close by year-end 2004.

During the development of the model, a vast amount of data and technical information was obtained from various Armenian government agencies,[1] utilities,[2] academic institutions[3] and other energy experts[4] working on energy efficiency projects within the country. Some data was obtained from reports produced from other USAID-sponsored energy projects in Armenia.

The real value from this project is the computer spreadsheet itself. While this report presents a concise overview of the model, the model and training provided will permit Armenian counterparts to use the model, learn from the outputs, and develop additional scenarios that may help to ensure that energy efficiency plays a proper role in the Armenian power sector. Further, the economic concepts (e.g., life cycle costing, time-value of money) embedded within the model are important within the context of the overall resource planning process and evaluating all potential resource options.

[1] Ministry of Energy, Energy Research Institute, Energy Regulatory Commission
[2] Yerevan Distribution Company, Central Distribution Company
[3] Yerevan Polytechnical University, Armenia University
[4] Association of Energy Engineers (Zohrab Melikyan, and others from the Armenian Chapter)

MODEL OVERVIEW

The initial evaluation of potential energy efficiency projects in Armenia can be accomplished using the screening model developed under this subtask. The tool is a computer spreadsheet (Microsoft Excel) model, developed in both English and Russian language versions, which allows the user to input values for certain variables, such as fuel prices, to determine whether a measure under consideration is economically viable for further consideration. For those measures that show positive results from the model, programs can be developed and implemented to promote their adoption throughout the country.

The model also allows the user to evaluate the potential environmental impacts (emissions) from the measures that are being considered. These benefits are shown in terms of the impact on the release of harmful emissions in kilograms per year based on displacing electricity generation.

For this report, data on fourteen separate measures were collected and evaluated using the model. These measures were selected to show the results of the model for various scenarios. However, the model user can examine other measures as desired. The user can use either the default input data or customize the data as needed.

As mentioned, the model is a computer spreadsheet model and is available on the enclosed disk. However, for this report, the hard copies of the spreadsheet are presented in the Appendix for documentation and review. It is anticipated that the model will be continually revised as additional, and more reliable, input data are gathered.

The output of the model is the life-cycle savings of the measure under consideration. This is in relationship to the technology that is being replaced. In most cases, it is the heating technologies that are considered, since these are the largest technological users of energy in the country at the present time and represent the greatest contribution to the peak electrical demand.

As shown in the Appendix, the shaded areas of the spreadsheets identify all of the input data values. The text on each page describes these values.

General Input

The general input into the model for each measure being considered includes technical data, emission data, financial data and other information about the technology under consideration. The user of the model can modify all of these data inputs, or the default values can be used. The technical data inputs include: the energy value of natural gas; the energy losses in the system; the efficiency of the thermal plants; and, the service life of the thermal plants.

The emission values input into the model are the combustion products from natural gas, in grams/joule, for CO_2, NO_X and SO_X. The default values contained in the model are those used by the Armenian government as they evaluate emissions from industrial facilities.

The financial data inputs include the current tariffs for electricity and natural gas and also the pricing periods for the electric time-of-day rates. The default values are the tariffs currently in place in Armenia. Also included are assumed discounts rates and the exchange rates (since the model converts the financial analyses to U.S. dollars).

Technology Specific Inputs

For all of the technologies, the user can input values for data that are specific to the programs that are being considered. There are inputs for old technologies, which are those that would be replaced by the new technologies, and the new technologies. The data inputs include technical, financial, and market potential.

The technical section contains some default values, but the user must input some of the values for the model to work. The input values include capacity requirements (input and output), operating periods, and repair time.

The Market Potential section includes inputs that are estimates of the penetration rates (i.e., number of customers with the technology) of the technologies under consideration.

The Financial section includes cost data (initial installed costs), maintenance costs, and a life cycle investment schedule and associated costs.

Summary Tables

The model produces two summary tables, that are useful for comparing the input values of different technologies. The first itemizes the technical inputs. Not only does it organize the specific technical data into a matrix, but it also converts fuel input from m^3/h to kW and converts the repair data from percentage figures to a fraction.

The financial summary shows the life cycle investment schedule data in U.S. dollars per year for each of the technologies. The model calculates the life cycle investment over a twenty-year period.

Technical Calculations

The technical calculations use the input data and default data to calculate the energy use of the existing and new technologies and then estimates the energy savings associated with the new technologies. The model also uses the emission data to calculate the changes in emissions using the new technologies. This is shown in kilograms per year for the old and new technologies.

Financial Calculations

Using all of the data inputs, the financial calculations result in the life cycle savings that the new technologies would produce. The model separates these into residential, medium voltage and high voltage customers. It shows the present value of the life cycle savings for each year of the life of the measure.

Emissions

The model also estimates the reductions that would be experienced from the lower energy usage by new technologies. This is provided in kilograms per year for CO_2, NO_X and SO_X.

APPENDIX DESCRIPTION

Because of the current situation in Armenia, in which the residential class of consumers is the primary end-user of energy, the emphasis of the screening model is aimed at measures that affect this class. The energy efficiency measures that were evaluated through the model and which are included in this report include:

- Weatherization;
- Micro Boilers and Cooking;
- Central Boilers;
- Small Electric Geothermal Heat Pumps;
- Large Electric Waste Heat Pumps;
- Large Gas Engine Driven Geothermal Heat Pumps;
- Small Gas Heaters, Domestic Hot Water, and Cooking;
- Gas Cooking;
- Fuel Cell Cogenerators;
- Natural Gas Engine Cogenerators;
- Wind Turbines;
- Street Lights;
- Room Lights; and,
- Televisions.

General Assumptions

To evaluate the technologies listed above, certain assumptions (technical, market potential and financial) were made. The following assumptions were used for all cases run by the model in order to evaluate all of the measures under the same criteria. The assumptions were made after data and other information was collected from various energy agencies and experts within Armenia.

Technical Assumptions

A number of technical assumptions were made including:

1. The existing technologies were considered in groups of 1,000 kW demand of aggregated equipment.

2. The energy consumption values are on an annual basis.

3. The levels of service (e.g., comfort) are assumed to be constant between the old and new technologies.

4. The annual electricity production in Armenia is 5.1 TWh, or which nuclear production is 28%, thermal 42% and hydro 30%. This average production mix is used to determine the emissions avoided from reduced electricity.[5]

5. The technical losses for the transmission and distribution systems are 10%. (This is low in reality but can be modified by the user).

6. The default heating season is considered to be 24 hours per day for 150 days annually, or 3,600 hours per year.

7. The heating demand per family is estimated as:

   a. Space heating – 670 watts, constant average for the entire heating season

   b. Domestic hot water – 390 watts, 6 hours per day

   c. Cooking – 170 watts, 6 hours per day

8. Weatherization is recommended as the priority heating measure; the heating load should be reduced before replacing heating appliances. Weatherization reduces the space heating loads by 30%.

[5] Generally, it is preferable to use a marginal emissions reduction estimate when such marginal emissions can be reliably estimated. Use of an average generation mix is a simplifying assumption.

9. It is assumed that two-thirds of the space heating is from the heating appliance and one-third from other sources.

10. The spreadsheet is designed for a maximum service life of 20 years.

Market Potential

The market potential for electricity generating technologies is only considered on the demand side of the customer meter. In other words, the possible benefits of sales to the grid have not been analyzed.

Financial Assumptions

The main financial assumptions include:

1. The model employs life cycle cost analysis using an assumed discount rate of 24 percent.

2. Savings witnessed by the end user will justify whether an energy efficiency measure is cost-effective.

3. The sole screening criterion is a savings-to-investment ratio (SIR) from the perspective of the end user. The model does not use lowest first cost and simple payback since such measures do not consider the time value of money.

4. A supplemental value, such as the cost of emissions, can be entered into the model in the event that there is a desire to monetize such emissions. This was not done in the current version of the model.

Flow Chart

The following page includes a flow chart of the model showing the inputs, the conversion of general input data, the technical calculations, the financial calculations and the outputs.

The Appendix illustrates the preliminary results of the model for each of the technology pairings. As with all simulation tools, the results are heavily dependent on the input data and the results need to be viewed in the context of prioritizing those measures on the basis of relative savings, not as strict quantitative data. The following table illustrates how the various demand reduction technologies compare in overall potential demand reduction:

Exhibit 2
Demand Reduction by Technology

Item	Efficiency Measure	% of Total
1	Weatherization	8
2	Boilers, Central	30
3	Waste Heat Pumps, Large Electric	14
4	Gas Heaters, DHW, Cooking	33
5	Sodium Streetlights	2
6	Compact Fluorescent Room Lights	13
	TOTAL	100

Source: Hagler Bailly

MODEL RESULTS

The Appendix provides the preliminary results of the model for each of the technology pairings. As with all simulation tools, the results are heavily dependent on the input data and the results need to be viewed in the context of prioritizing those measures on the basis of relative savings, not as strict quantitative data. The following table illustrates how the various demand reduction technologies compare in overall potential demand reduction:

Exhibit 1
Demand Reduction by Technology

Item	Efficiency Measure	% of Total
1	Weatherization	8
2	Boilers, Central	30
3	Waste Heat Pumps, Large Electric	14
4	Gas Heaters, Hot Water and Cooking	33
5	Streetlights (Sodium Vapor)	2
6	Compact Fluorescent Room Lights	13
	TOTAL	100

Source: Hagler Bailly

The preliminary results indicate that central boilers, gas heaters, hot water, and cooking measures could account for 66% of the total potential savings in Armenia (for the measures examined). These results would then have to be weighed against the required investment, project development time, replicability, and other factors in order to arrive at a final recommendation and estimate of investment versus savings. The model provides a valuable tool in which the field of applicable measures can be investigated by refining input data and assumptions to arrive at a quantitative evaluation. This information would then provide the basis of a project evaluation, financial analysis, evaluation of potential funding sources, and payback mechanisms. The model also provides a valuable monitoring and tracking tool in which the results of measures and programs can be assessed against their initial estimation.

The Hagler Bailly report *Armenia – Final Report on the Demand-Side Management Project* (March 2000) describes the results of the analysis, estimates the peak coincident savings that can reasonably be expected to be achievable by the time of the planned nuclear plant shutdown, and the measures costs associated with promotion of the more efficient technology. Additionally, the report provides several recommendations for promoting energy efficiency in Armenia.

CONCLUSION

The screening tool developed for this project provides a comprehensive way to assess the effectiveness of various efficiency measures in Armenia. An important component of this project was the collection of up-to-date information on technology usage, technology costs and market penetration. Use of the model has revealed a number of measures that appear cost-effective for further investigation and ideally, promotion, including primarily those measures that are targeted at reducing, or replacing, electric heating consumption in households. Further, the fact that the model has been written in both English and Russian language versions increases the likelihood that the model can be of use both within and outside of Armenia.

In terms of next steps, Hagler Bailly will use the tool as part of the energy efficiency program component of Task Order 13 to both: (1) design the pilot efficiency and fuel substitution program; and, (2) develop an illustrative energy conservation plan for Armenia. Additionally, as further work is completed on the least cost generation expansion plan for Armenia, improved data on avoided costs and emissions can be included in the model to enhance its accuracy. Expanded user training for Armenian counterparts is also anticipated.